RESEARCH AND DEVELOPMENT OF FUNDAMENTAL PERFORMANCE INFORMATION RELEVANT TO THE BEHAVIORAL EFFECTS OF LOW LEVEL MICROWAVE EXPOSURE

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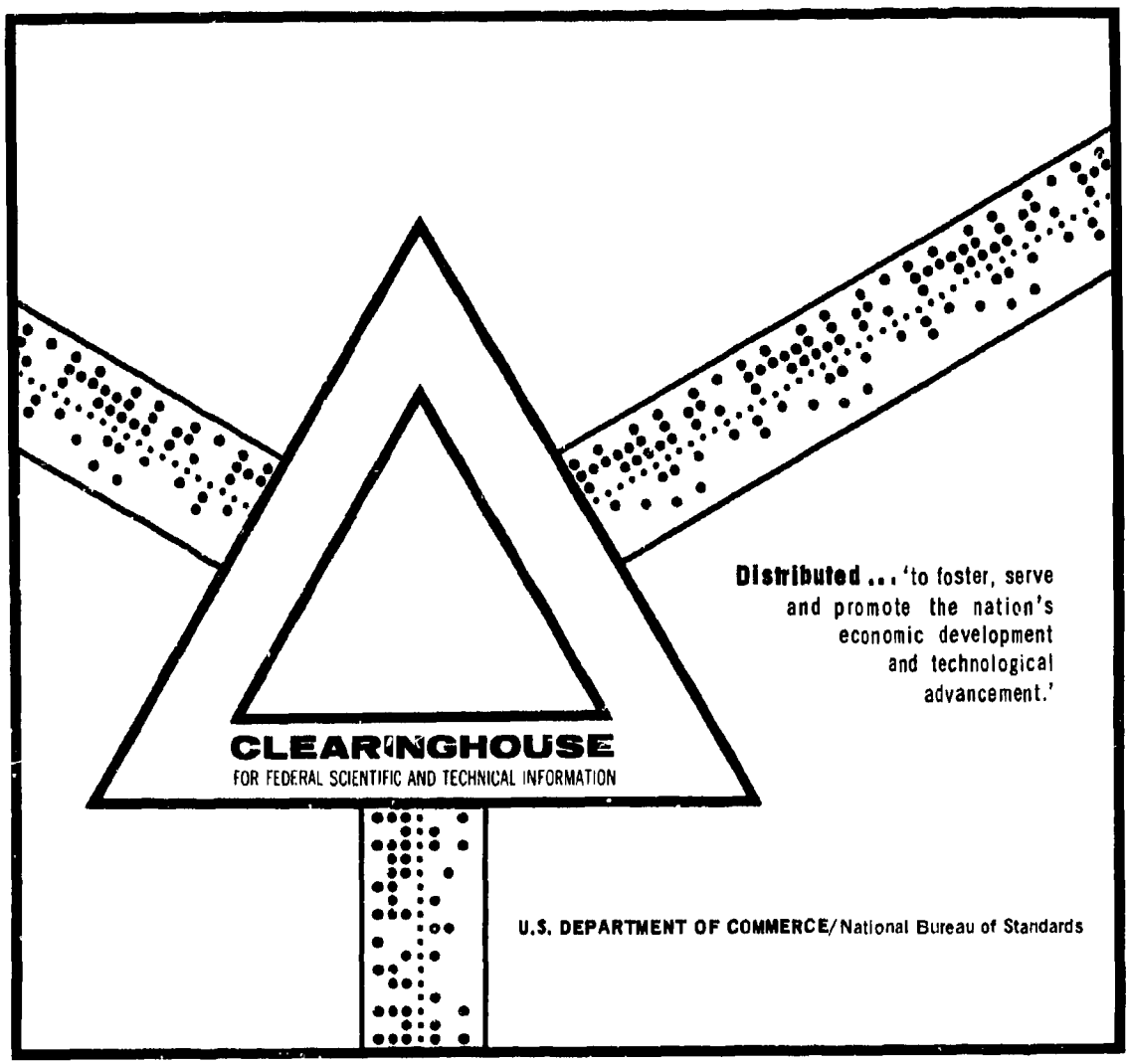

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Research and Development of Fundamental Performance Information Relevant to the Behavioral Effects of Low Level Microwave Exposure.

Annual Summary Report

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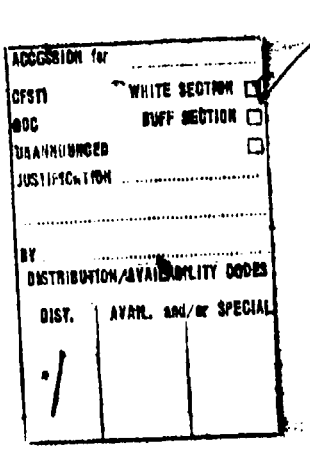
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Summary

This is a preliminary report covering the first year of a research program designed to provide information on the behavioral effects of low-level microwave radiation. A laboratory facility has been established for an experimental analysis of the performance of primates exposed to a specified microwave field and experimental methods have been developed which will permit the assessment of changes in complex behavior resulting from acute and chronic exposure to a low-level microwave field of defined frequencies. In addition, methods are being developed for assessing biochemical effects of microwave exposure under conditions related to such performance changes.

Foreword

In conducting the research described in this report, the investigators adhered to the "Guide for Laboratory Animal Facilities and Care," as promulgated by the Committee on the Guide for Laboratory Animal Resources, National Academy of Sciences - National Research Council.

Body of Report

Statement of Problem

The purpose of this research program is to establish a laboratory facility for an experimental analysis of the behavioral effects of low-level microwave radiation and assess the biological effects of acute and chronic exposure to microwave radiation with particular reference to performance changes. The research program focuses specifically on relating changes in the complex behavior and biological functioning to include biochemical processes of primates to exposure to a microwave energy field below 10 mw/cm^2. The objectives of this investigative program are being closely coordinated with the microwave research program at the Walter Reed Army Institute of Research.

Background

The biological effects of nonionizing microwave irradiation have been the object of a rapidly expanding scientific literature concerned primarily with anatomical and physiological changes involving the central and autonomic nervous system, the endocrine system, and peripheral sensory motor mechanisms (Thompson and Bourgeois, 1965). Relatively few systematic experimental studies of behavioral changes related to low-level microwave exposure have been reported, however, and little or no attention has been directed toward the analysis of complex performances in advanced organisms (i.e., primates, including man) under such conditions. Micro-organisms have been shown to

make specific orienting responses in a microwave field (Brown and Morrison, 1956; Blois, 1956) and changes in response latency and frequency have been reported in simple conditioning experiments with laboratory rodents exposed to low power density fields (Gordon, 1962; Subbota, 1958; Lobanova and Tolgskaya, 1962). Two additional studies have suggested that modifications in memory and learning may occur in lower animals as a result of microwave exposure (Justesen, Pendleton, and Porter, 1961; Bryan, 1966) and general motor activity changes have been frequently reported under such conditions (Pinneo, Baus, McAfee, and Fleming, 1962; Fleming, Pinneo, Baus and McAfee, 1961; Eakin and Thompson, 1965). Also, exposure to a moderate intensity microwave field at 388 Mhz has been reported to produce agitation, drowsiness, and akinesia in monkeys (Baldwin, Back, and Lewis, 1960). Clinical observations of humans exposed to microwave fields have suggested that such motor effects may be accompanied by sleep disturbances, a lower resistance to fatigue, increased irritability, and memory concentration deficits (Kevork'ian, 1948; Sercl, et al, 1961; Edelwejn & Haderich, 1962; Sadchekova & Orlova, 1959; Jaski, 1960; Sadchekova, 1962). At present, a need clearly exists for a more precise specification of the behavioral processes which are selectively sensitive to microwave effects so that reliable correlations with anatomical, physiological, and biochemical changes can provide a better understanding of the mechanisms involved in such performance decrements.

Approach

The investigation of the relationship between microwave exposure and performance decrements has capitalized upon available research data and

technological developments emerging from the laboratory analysis of performance changes under a wide variety of internal and external environmental conditions. Several areas in particular, dealing with temporal control (response latency and timing performances) and the maintenance of high work loads under both appetitive and aversive control (progressive ratio and second order avoidance performances) appear to provide relevant and potentially sensitive baselines for the assessment of microwave effects upon behavior.

Additionally, an expanding literature on the role of biogenic amines in regulatory and neuroconductive processes suggests the possibility of a controlling relationship between such biochemical factors and the biological effects of microwave irradiation. Available methods for assessing the metabolic fate of catecholamines and polyamines as well as the enzymes involved in their biosynthesis, distribution, and metabolism are being explored as sensitive indicators of microwave effects, and their relationship to behavioral changes involving autonomic and neuroendocrine functions will be studied.

The research program continues to involve close coordination with the Behavioral Radiology Laboratory at the Walter Reed Army Institute of Research to insure maximum contribution to the existing programs involving microwave research. The initial experiments are being prepared for the exposure of laboratory primates to microwave fields in the 10 cm wavelength range at power levels below 10 mw/cm^2.

Methods and Procedures

In preparation for these studies, rhesus monkeys have been restrained in and adapted to specially designed Plexiglas primate chairs and trained to perform on an attached work panel providing a telegraph key, a speaker, and several stimulus lights. Daily experimental sessions have been conducted in a specially constructed RF shielded chamber (8' x 8' x 20') designed to specification by Emerson and Cumming (Canton, Mass.). The animals have been trained to perform on a multiple schedule for food reinforcement during daily experimental sessions of 9 hours duration, the interval during which daily microwave exposures will occur. The multiple schedule program consists of recurrent exposure to periods of a progressive ratio (PR) requirement alternating with periods of a differential reinforcement of low rate (DRL) requirement with 30-minute S^{Δ} or "time out" periods interspersed between each schedule change. Exposure to the progressive ratio schedule is signalled by a clicking noise in the presence of which 40 responses on the telegraph key are required to produce the first food reinforcement, 80 additional responses required to produce the second food reinforcement, 160 additional responses required for the third, and so on in progression to 640 responses for the fifth food reinforcement. After the 5th food reinforcement (or one hour of elapsed time, whichever comes first), the clicking noise is terminated and a tone is sounded for 30 minutes during which telegraph key responses do not produce food under any conditions (S^{Δ} or "time out"). Following this 30-minute S^{Δ} period, a red light stimulus is presented on the work panel and telegraph

key responses are reinforced with food on a schedule which requires the spacing of responses at least 90 seconds apart in order to produce food. After 5 reinforcements or one hour, whichever occurs first, the stimulus light is terminated and the S^{Δ} or "time out" tone is presented for 30 minutes before recycling of the progressive ratio schedule and beginning the entire sequence again.

Concurrently with the establishment of the performance baseline, complimentary studies have been initiated to develop bioassay and histochemical methods for assessing catecholamine and polyamine synthesis, distribution and metabolic turnover rates as potentially sensitive indicators of microwave and behavioral effects. Analytic procedures for the detection of catecholamines and polyamines in animal tissues, particularly the central nervous system and in body fluids are being tested in include electrophoretic techniques in cold plate for polyamine separations and fluorometric and radiometric techniques for catecholamines.

The microwave generating, amplifying, and modulating system provides for exposure to microwave fields in the 10 centimeter frequency range at power levels below 10 mw/cm^2. Effects related to frequency and amplitude modulation of the wave form within 1 hz/sec to 1 khz/sec and 0-100% range respectively, are of particular interest in the initial focus of the experimental program.

Results and Discussion

Research efforts during the first year of the project have been concerned primarily with the establishment of the laboratory facility, development and

testing of biobehavioral assessment procedures, and training of laboratory primates on the baseline performances against which microwave effects will be evaluated.

Establishment of the laboratory facility has required the design, fabrication, and installation of a variety of specialized equipment items to satisfy the unique demand of microwave research. The RF shielded chamber, designed to specifications as indicated above, has been assembled and installed in the laboratory area and essential accessory equipment to include a water delivery system and plexiglas primate restraining chairs for the experimental subjects designed to minimize interference with the microwave signal have been constructed according to specification. A remotely controlled solid state programming and recording system has been developed and integrated with the stimulus and response accessories provided in the immediate experimental environment of the laboratory primate subjects. Interconnecting circuitry has been tested under operational conditions. All of the electronic components required to generate and control the microwave signal have been ordered, and with the sole exception of the main power amplifier, deliveries have been made and installation of the system is in process. Receipt of the power amplifier delayed for over six months by technical problems encountered by the sole supplier (Lytton Industries) is now projected before the end of the first contract year and calibration, testing, and experimental application of the system will be accomplished immediately.

Preliminary studies to determine the most effective and sensitive behavioral performance parameters have been completed with rhesus monkeys in the

primate restraining chair situation and the training procedure described above has been initiated. Two animals subjected to the training routine during daily sessions over a period of several weeks are approaching stable performance baseline levels against which the effects of microwave exposure can be evaluated. Additional animals are being used to explore the feasibility of developing methods for assessing more refined aspects of stimulus control processes as these may relate to microwave effects and to provide a backup resource for the initial laboratory animal subject pool.

Initial studies of bioassay and histochemical methods for detection and assessment of biochemical changes related to microwave exposure have focused upon testing procedures for determining polyamine turnover rates in animal tissue. Polyamine metabolism in both the liver and the brain of rodents has thus far been studied to determine the most effective baseline procedures to be used in future primate experiments. Preliminary evaluation of available analytic methods for catecholamine detection in the central nervous system and body fluids has also been undertaken with a view to integrating critical information about their broad role in overall hormonal regulation in relationship to microwave effects.

Conclusions

Available behavioral and biochemical methods appear adequate to satisfy the objectives of the present research program directed toward the assessment of biological effects of microwave exposure. The laboratory facility which

has been established to pursue these investigative efforts is capable of a comprehensive, in-depth analysis of the indicated research problem area and the requisite personnel and equipment resources for successful pursuit of such multidisciplinary experimental inquiry are rapidly becoming available within the framework of the present program

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SOCIAL SECURITY ACCOUNT NUMBER:

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23. TECHNICAL OBJECTIVE,* 24. APPROACH, 25. PROGRESS *(Furnish individual paragraphs identified by number. Precede text of each with Security Classification Code.)*

25. PROGRESS. A laboratory has been established which incorporates the features requisite for an experimental analysis of the behavioral effects of exposure to low-level microwave fields. The facilities of this laboratory include a specially-designed primate restraining apparatus, an RF shielded testing environment, an isolation area for preparing and maintaining test subjects, the microwave signal generating system, and equipment for programming environmental events and recording appropriate behavioral changes. The various components comprising the experimental situation are being coordinated and tested under operational conditions. Primate subjects have undergone the necessary transfer and quarentine procedures, have been habituated to the experimental environment, and have been trained on the behavioral baseline procedures in the restraining units which will permit long-term study of complex performances during microwave exposure. In addition, methods are being developed for assessing biochemical effects of microwave exposure under conditions related to such performance changes.

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13. ABSTRACT

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